Abstract

GLOBAL HYPERSPECTRAL IMAGING OF PEROVSKITE CRYSTALS AND SOLAR CELLS USING PHOTOLUMINESCENCE AND TRANSMITTANCE MEASUREMENTS

LAURA-ISABELLE DION-BERTRAND[1*], DAVID G. COOKE[2], DAVID VALVERDE-CHAVEZ[2], HADI RAZAVIPOUR[2], YANG LAN[2], CONSTANTINOS C. STOUMPOS[3], MERCOURI KANATZIDIS[3], GILBERT EL-HAJJE[4,5], CRISTINA MOMBLONA[6], LIDON GIL-ESCRIG[6], JORGE ÁVILA[6], THOMAS GUILLEMOT[5,8], JEAN-FRANÇOIS GUILLEMOLES[5,7], MICHELE SESSOLO[6], HENK J. BOLINK[6] and Jean-Paul GASTON[9]

1 Photon etc. ltd, Montréal, H2S 2X3, Canada.:
2 Department of Physics, McGill University, Montréal, Québec, Canada H3A 2T8
3 Department of Chemistry, Northwestern University, Evanston, Illinois 60208, USA
4 EDF R&D, 6 quai Watier, 78400 Chatou, France
5 Institut Photovoltaïque d'Ile de France (UMR IPVF), 18 Bd Thomas Gobert, 91120 Palaiseau, France
6 Instituto de Ciencia Molecular, Universidad de Valencia, C/Catedrático J. Beltrán 2, 46980 Paterna, Spain.
7 NextPV, CNRS-RCAST joint lab, Tokyo University, 4-6-1 Komaba, Meguro-ku 153-8904, Tokyo, Japan
8 ECE Paris, Laboratoire Licorne, 37 Quai de Grenelle, 75015 Paris, France
9 OPTON Laser, ZA Courtaboeuf, 6, Av des Andes, Bât 8 , 91940 Les Ulis, France

The photovoltaics landscape changed drastically over the past few years with the rapid evolution of organometallic perovskite solar cells. Their high carrier mobility, tuneable band gap and strong absorption in the visible make it an excellent candidate for the production of low cost and high efficiency solar panels. However, their stability is precarious, and their current lifetime (~ 2000 solar peak hours) is still pretty low. In order to take this new material to the market, a better understanding of the photo-physics and the degradation mechanisms is necessary. With this in mind, vacuum evaporated perovskite solar cells and perovskite single crystals were characterized using hyperspectral imaging. Spectrally resolved photoluminescence (PL), electroluminescence (EL) and transmittance maps were acquired on different samples over a million points with a spatial resolution close to one µm. PL and transmittance maps of a perovskite crystal aged in air showed strong inhomogeneities, highlighting surface defects, grain boundaries, phase segregation and disorder. Furthermore, PL and EL maps of perovskite devices were coupled with absolute calibration method in order to obtain the exact number of photons emitted from every point of the device, at every wavelength. Using the generalized Planck's law, it is possible to obtain maps of the depth-averaged quasi-Fermi level splitting (Δµ), which dictate the maximum achievable open circuit voltage (Voc) of solar cells. Also, using the generalized reciprocity relations the charge transfer efficiency of the cells can be analyzed from the hyperspectral data. Once again, considerable spatial inhomogeneities, both in quasi-Fermi level splitting (Δµ) and in charge transfer efficiency, are found in these perovskite devices. Hence, hyperspectral imaging provides a useful insight of the local composition and electronic properties of perovskite solar cells which will contribute to understand physical properties at a micron scale level and significantly help improving their overall performances.